Citation:

Diehr P, O'Meara ES, Fitzpatrick A, Newman AB, Kuller L, Burke G. Weight, mortality, years of healthy life, and active life expectancy in older adults. *J Am Geriatr Soc.* 2008 Jan;56(1):76-83.

PubMed ID: 18031486

Study Design:

Longitudinal Cohort Study

Class:

B - Click here for explanation of classification scheme.

Research Design and Implementation Rating:

NEUTRAL: See Research Design and Implementation Criteria Checklist below.

Research Purpose:

- To use transition probabilities and multistate life tables to examine concurrent changes in weight and health status over time in adults
- To examine the relationship between weight and health after age 65
- To address the question of whether "normal" weight, which is defined without reference to age, is indeed associated with the best health in older adults, as measured according to total, healthy, and active life expectancy

Inclusion Criteria:

Must have participated in the Cardiovascular Health Study (CHS).

Exclusion Criteria:

None described.

Description of Study Protocol:

Recruitment

Participants of CHS were recruited from a random sample of people eligible for Medicare in four US communities.

Design: Longitudinal population-based cohort study

Blinding used (if applicable): not applicable

Intervention (if applicable)

- Extensive data was collected on the original cohort at 10 annual visits. A supplemental cohort had up to seven annual examinations.
- At each of the visits, Future Years of Life (YOL), Years of Healthy Life (YHL), and Active Life Expectancy (ALE) was determined by asking participants to rate their health.
- Weight was measured every year and height was measured up to three times during follow-up. Height and weight were used to calculate Body Mass Index (BMI).

Statistical Analysis

- Linear interpolation was used to impute missing data when values were known at clinic visits before and after the missing value.
- Each CHS participant was classified into:
  - one of four BMI states (underweight, normal, overweight, or obese) and
  - one of two health states (healthy or sick; with or without Activities of Daily Living (ADL) difficulties for analysis of ALE)
  - an additional category was added if they died
- Approximately 40,000 transition pairs were created, from age 65-95 (A transition pair is an observation of two BMI and health states for the same person, 1 year apart)
- Linear discriminant analysis was used to analyze the age- and sex- specific probability of transition from one BMI-by-health state to another to predict the state the next year as a function of the current state and logarithm of age.
- A spreadsheet was programmed to perform multistate life table calculations, and the program was applied to eight hypothetical cohorts of 100,000 women, one for each BMI-by-Health state at age 65.
- The program calculated the expected number of women (and separately for men) in each BMI-by-health state at age 66, at age 67, and so on.
- Estimates were summed and divided by 100,000 to calculate expected YOL, YHL (or ALE), and years spent in each BMI category for each hypothetical cohort.
- To estimate the standard error of YOL, YHL, and ALE, the 5,888 persons were resampled 100 times (with replacement), and the entire set of calculations was performed for each new dataset.
- The standard deviations among the 100 sample estimates of the various quantities were used in the final analysis to calculate approximate *t* statistics.

Data Collection Summary:

Timing of Measurements

- Members of the original cohort (n=5201) were recruited in 1989/1990 and had up to 10 annual visits
- A supplemental cohort of 687 African Americans were recruited in 1992/1993 and had up to 7 annual visits.

Dependent Variables

- YOL (Future years of Life) - defined as life expectancy from age 65 to death
- YHL (Years of Healthy Life) - defined on the basis of self-rated health
  - Participants were asked to rate their health as excellent, very good, good, fair, or poor
  - Defined as the expected number of years in which a person was healthy (in excellent, very good, or good health) versus sick (fair or poor health)
- ALE (Active Life Expectancy) - defined as the expected number of years of future life spent with no difficulties in activities of daily living (ADL)
  - Participants were asked every year whether, because of health or physical problems, they had any difficulty walking around at home, getting out of bed or a chair, eating, bathing or showering, or using the toilet
  - A person with a positive response to any of these items was considered to have an ADL difficulty at that time

Independent Variables

- BMI (Body Mass Index) calculated as weight in kilograms divided by the square of height in meters
- BMI for this study was classified according to the following:
  - Underweight: 20.0 or lower
  - Normal weight: 20.1-24.9
  - Overweight: 25.0-29.9
  - Obese: 30.0 or higher

Control Variables

Description of Actual Data Sample:

Initial N:

- Members of the original cohort (n=5201) were recruited in 1989/1990
- A supplemental cohort of 687 African Americans were recruited in 1992/1993

Attrition (final N): N= 5888

Age: age 65 and older at baseline, mean age of the cohort was 75.7 years

Ethnicity: not described in detail. Original cohort sampled were persons eligible for Medicare from 4 US communities; an additional cohort of African Americans was later sampled.

Other relevant demographics:

Anthropometrics

Location: 4 US communities

Summary of Results:

Key Findings

- Although persons were most likely to remain in the same state, there was substantial movement between states as well.
- Persons moved from healthy to sick and from sick to healthy the following year.
- Persons gained and lost weight, although they rarely moved more than one BMI category in a single year.
- Underweight persons were approximately 3 years older than obese persons on average.
- The proportion of healthy and normal-weight men who were sick or dead 1 year later rose from approximately 9% at age 65 to 69 to 27% at age 90 to 94
  - For women, this probability increased from 4% to 28%
- These probabilities were worse (higher) for the other initial BMI-by-health states except for healthy overweight, which is similar to healthy normal.
- For healthy normal-weight men, the probability of becoming overweight or obese in the following year declined from approximately 16% at age 65 to 69 to 11% at age 90 to 94; for women the decline was from 13% to 3%

Initial State	Dead	Underweight	Normal	Overweight	Obese	Underweight	Normal	Overweight	Obese	Total (n)
Sick underweight	13.1	53.0	9.6	0.2	0.2	18.1	5.3	0.3	0.2	581
Sick normal	9.0	4.2	51.7	5.7	0.1	1.2	25.0	3.2	0.0	2759
Sick overweight	5.1	0.1	7.3	51.7	4.1	0.0	2.7	27.3	1.6	3352
Sick Obese	3.6	0.0	0.1	7.6	59.4	0.0	0.1	2.8	26.3	2228
Healthy underweight	3.7	11.9	2.0	0.1	0.0	67.8	14.4	0.1	0.1	1228
Healthy normal	1.8	0.7	8.4	0.8	0.0	2.4	77.0	8.9	0.0	10221
Healthy overweight	1.3	0.0	1.5	8.0	0.6	0.0	6.9	77.9	3.9	13432

Healthy Obese	1.2	0.0	0.0	1.5	11.4	0.0	0.1	8.6	77.2	5856
Total, n	1051	647	2812	3304	2211	1262	9794	12947	5689	39717

Other Findings

- Multistate life table methods were used to examine these complex relationships further.
- The estimated health trajectory for a hypothetical cohort of 100,000 women and men who were healthy and of normal weight at age 65 was examined.
  - All were healthy at age 65
  - The number of healthy persons decreased regularly over time
  - Number of dead increased
  - Number of sick persons waxed and then waned.
- Healthy overweight women and healthy obese men had the longest estimated life expectancy, whereas healthy normal-weight women and healthy overweight men had the most years of healthy life.
- Estimated BMI trajectories for a hypothetical cohort of 100,000 women and men who were healthy and of normal weight was examined
  - Within 1 year (at age 66), fully 15% of this hypothetical cohort was overweight, and the number of overweight increased further over time and then decreased as the number of dead increased.
- On average, persons will spend the majority of their remaining life in the BMI state they were in at age 65.

Author Conclusion:

- This article supports the idea that guidelines for weight should be age-appropriate, not "one size fits all"
- Older adults who are overweight (or, for men, even obese) may be at a healthy weight for their age
- The current BMI and weight standards would seem to detract from appropriate concern for underweight, which has been shown to be a more-important concern for older adults.

Reviewer Comments:

Several limitations were mentioned:

- *Persons who enrolled in the CHS were relatively healthy for their age at baseline.*
- *Even though most of the data used here were collected long after baseline, the results may be overly favorable when compared with the general population.*
- *The data were collected before the current obesity epidemic, suggesting that today's overweight and obese elderly people may be different from their counterparts measured in the 1990s.*
- *For the multistate life tables in this article, 72 probabilities needed to be estimated for each year of age according to sex (5320 probabilities in all), and YOL, YHL, and ALE may be poorly estimated in the smallest cells.*
- *The standard errors for YHL and YOL in the initially sick and underweight category were large.*
- *Many differences between states were small and may not be clinically important.*
- *In the boot-strap procedure used to estimate the standard errors, it was not possible to duplicate the complex calculations exactly, and the t-statistics used are only approximate.*

Research Design and Implementation Criteria Checklist: Primary Research

Relevance Questions

1.	Would implementing the studied intervention or procedure (if found successful) result in improved outcomes for the patients/clients/population group? (Not Applicable for some epidemiological studies)	Yes
2.	Did the authors study an outcome (dependent variable) or topic that the patients/clients/population group would care about?	Yes
3.	Is the focus of the intervention or procedure (independent variable) or topic of study a common issue of concern to nutrition or dietetics practice?	Yes
4.	Is the intervention or procedure feasible? (NA for some epidemiological studies)	Yes

Validity Questions

1.	**Was the research question clearly stated?**	Yes
1.1.	Was (were) the specific intervention(s) or procedure(s) [independent variable(s)] identified?	Yes
1.2.	Was (were) the outcome(s) [dependent variable(s)] clearly indicated?	Yes
1.3.	Were the target population and setting specified?	Yes
2.	**Was the selection of study subjects/patients free from bias?**	Yes
2.1.	Were inclusion/exclusion criteria specified (e.g., risk, point in disease progression, diagnostic or prognosis criteria), and with sufficient detail and without omitting criteria critical to the study?	Yes

2.2.	Were criteria applied equally to all study groups?	Yes
2.3.	Were health, demographics, and other characteristics of subjects described?	Yes
2.4.	Were the subjects/patients a representative sample of the relevant population?	Yes
3.	**Were study groups comparable?**	Yes
3.1.	Was the method of assigning subjects/patients to groups described and unbiased? (Method of randomization identified if RCT)	Yes
3.2.	Were distribution of disease status, prognostic factors, and other factors (e.g., demographics) similar across study groups at baseline?	Yes
3.3.	Were concurrent controls used? (Concurrent preferred over historical controls.)	Yes
3.4.	If cohort study or cross-sectional study, were groups comparable on important confounding factors and/or were preexisting differences accounted for by using appropriate adjustments in statistical analysis?	Yes
3.5.	If case control or cross-sectional study, were potential confounding factors comparable for cases and controls? (If case series or trial with subjects serving as own control, this criterion is not applicable. Criterion may not be applicable in some cross-sectional studies.)	N/A
3.6.	If diagnostic test, was there an independent blind comparison with an appropriate reference standard (e.g., "gold standard")?	N/A
4.	**Was method of handling withdrawals described?**	Yes
4.1.	Were follow-up methods described and the same for all groups?	Yes
4.2.	Was the number, characteristics of withdrawals (i.e., dropouts, lost to follow up, attrition rate) and/or response rate (cross-sectional studies) described for each group? (Follow up goal for a strong study is 80%.)	Yes
4.3.	Were all enrolled subjects/patients (in the original sample) accounted for?	Yes
4.4.	Were reasons for withdrawals similar across groups?	Yes
4.5.	If diagnostic test, was decision to perform reference test not dependent on results of test under study?	N/A
5.	**Was blinding used to prevent introduction of bias?**	Yes
5.1.	In intervention study, were subjects, clinicians/practitioners, and investigators blinded to treatment group, as appropriate?	N/A
5.2.	Were data collectors blinded for outcomes assessment? (If outcome is measured using an objective test, such as a lab value, this criterion is assumed to be met.)	N/A
5.3.	In cohort study or cross-sectional study, were measurements of outcomes and risk factors blinded?	Yes
5.4.	In case control study, was case definition explicit and case ascertainment not influenced by exposure status?	N/A
5.5.	In diagnostic study, were test results blinded to patient history and other test results?	N/A
6.	**Were intervention/therapeutic regimens/exposure factor or procedure and any comparison(s) described in detail? Were interveningfactors described?**	Yes
6.1.	In RCT or other intervention trial, were protocols described for all regimens studied?	N/A
6.2.	In observational study, were interventions, study settings, and clinicians/provider described?	Yes
6.3.	Was the intensity and duration of the intervention or exposure factor sufficient to produce a meaningful effect?	Yes
6.4.	Was the amount of exposure and, if relevant, subject/patient compliance measured?	N/A
6.5.	Were co-interventions (e.g., ancillary treatments, other therapies) described?	N/A
6.6.	Were extra or unplanned treatments described?	N/A
6.7.	Was the information for 6.4, 6.5, and 6.6 assessed the same way for all groups?	N/A
6.8.	In diagnostic study, were details of test administration and replication sufficient?	N/A
7.	**Were outcomes clearly defined and the measurements valid and reliable?**	Yes

	7.1.	Were primary and secondary endpoints described and relevant to the question?	Yes
	7.2.	Were nutrition measures appropriate to question and outcomes of concern?	Yes
	7.3.	Was the period of follow-up long enough for important outcome(s) to occur?	Yes
	7.4.	Were the observations and measurements based on standard, valid, and reliable data collection instruments/tests/procedures?	Yes
	7.5.	Was the measurement of effect at an appropriate level of precision?	Yes
	7.6.	Were other factors accounted for (measured) that could affect outcomes?	No
	7.7.	Were the measurements conducted consistently across groups?	Yes
8.	**Was the statistical analysis appropriate for the study design and type of outcome indicators?**		No
	8.1.	Were statistical analyses adequately described and the results reported appropriately?	Yes
	8.2.	Were correct statistical tests used and assumptions of test not violated?	Yes
	8.3.	Were statistics reported with levels of significance and/or confidence intervals?	No
	8.4.	Was "intent to treat" analysis of outcomes done (and as appropriate, was there an analysis of outcomes for those maximally exposed or a dose-response analysis)?	N/A
	8.5.	Were adequate adjustments made for effects of confounding factors that might have affected the outcomes (e.g., multivariate analyses)?	No
	8.6.	Was clinical significance as well as statistical significance reported?	No
	8.7.	If negative findings, was a power calculation reported to address type 2 error?	N/A
9.	**Are conclusions supported by results with biases and limitations taken into consideration?**		Yes
	9.1.	Is there a discussion of findings?	Yes
	9.2.	Are biases and study limitations identified and discussed?	Yes
10.	**Is bias due to study's funding or sponsorship unlikely?**		Yes
	10.1.	Were sources of funding and investigators' affiliations described?	Yes
	10.2.	Was the study free from apparent conflict of interest?	Yes